

Photonic Crystal Fibres

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Photonic crystal fibres (PCFs – sometimes also known as “holey” or “microstructured” fibres) have been the focus of increasing scientific and technological interest since the first working example was reported in 1996 [1,2]). Although superficially similar to a conventional optical fibre, PCF has a unique microstructure, consisting of an array of microscopic holes (or channels) running along the entire fibre length. These holes act as optical barriers or scatterers, which suitably arranged can “corral” light within a central core (either hollow or made of solid glass). The holes can range in diameter from ~25 nm to ~50 μm . Although most PCF is formed in pure silica glass, it has also recently been made using polymers [3] and non-silica glasses [4], where it is difficult to find compatible core and cladding materials suitable for conventional total internal reflection guidance.

PCF supports two guidance mechanisms: total internal reflection, in which case the core must have a higher average refractive index than the holey cladding; and a two-dimensional photonic bandgap, when the index of the core is uncritical – it can be hollow or filled with material [2]. Light can be controlled and transformed in these fibres with unprecedented freedom, allowing for example the guiding of light in a hollow core, the creation of highly nonlinear solid cores with anomalous dispersion in the visible and the design of fibres that support only one transverse spatial mode at all wavelengths. Applications are emerging in many diverse areas of science and technology.

For example, as first shown by Ranka et al [5], an ultra-small core fibre made from solid glass and surrounded by very large air-holes can be arranged to have a zero chromatic dispersion wavelength in the 800 nm Ti:sapphire band. This fibre produces spectacular spectral broadening of high repetition rate 100 fsec pulses, with a brightness some 10,000 \times brighter than the sun and a similar bandwidth. This source is transforming the fields of optical coherence tomography, spectroscopy and frequency metrology [5]. Recently a record-breaking supercontinuum spectrum, extending out to 2300 nm, has been demonstrated in a SF6 glass fibre (see Figure).

In its hollow core form [7], PCF also solves a key long-standing challenge in photonics, for which there is no good conventional solution: How to force light to interact – strongly, reproducibly and over long path-lengths – with low-density materials such as gases, vapours and liquids. This is an exciting development with major implications for numerous gas-based nonlinear optical and laser devices. Recently a hydrogen Raman cell was demonstrated [8] with a threshold energy of 800 nJ – some 100 \times lower than previously reported. In September 2002, breakthrough losses of 13 dB/km were reported in hollow-core photonic bandgap fibre by a team from Corning [7]. Fully characterised hollow core PCF is now commercially available with losses below 0.1 dB/m [10].

These two examples illustrate how the PCF concept is ushering in a new and more versatile era of fibre optics, with a multitude of different applications spanning many areas of science and technology.

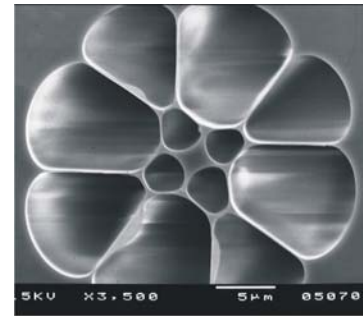


Figure: Extruded SF6 glass fibre for producing a super-continuum out to 2300 nm

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